LEGUME PERSPECTIVES

Phaseolus: A New World gift to mankind

Why common beans are so common?

The journal of the International Legume Society

Issue 2 • April 2014

IMPRESSUM

ISSN
2340-1559

Quarterly publication
January, April, July and October,
with an open possibility of additional issues

Published by
International Legume Society

Office
CSIC, Institute for Sustainable Agriculture
Apdo. 4084, 14080 Córdoba, Spain
Phone: +34957499215 • Fax: +34957499252

Subscriptions
Office
(diego.rubiales@ias.csic.es)

Cover photo
Marta Santalla Ferradas

FOR AUTHORS

Legume Perspectives is an international peer-reviewed journal aiming to interest and inform a worldwide multidisciplinary readership on very different aspects of legume research and use, including genetics, agronomy, animal production, human nutrition and health and economics.

Please write your article so that it will assist in the exchange of information between people working in different expert fields of legume research: write to the length requested; provide a review of the most important information on your topic; try to avoid (or explain) specialist words, unusual jargon and acronyms; emphasise results and conclusions; choose titles carefully and add subheadings that tell readers something. *Legume Perspectives* prefers a clear, simple and comprehensive writing style that would make its articles interesting and useful for both academic and amateur audience. Your manuscripts does not have to follow the usually strict structure of the research papers.

We strongly encourage you to submit either longer (1,250 words + 2 tables, figures or photos + up to 8 references) or shorter (450 words + 1 table, figure, photograph or drawing + up to 4 references) manuscripts. The Editorial Board may allow any variation from case to case. Please provide also an additional abstract of between 90 and 100 words and from 4 to 6 key words listed alphabetically.

The manuscripts should be prepared in Microsoft Office Word, using Times New Roman font, 12 points size. The references should be listed and numbered alphabetically, following the style of any of the published papers in this issue. The tables may be incorporated in the manuscript, while it is desirable that figures, photographs or drawings are submitted separately preferably as jpg files.

Please send your prepared manuscripts or any inquiries on publishing in *Legume Perspectives* to diego.rubiales@ias.csic.es or legume.society@gmail.com

Nuña popping bean: a kind of witness of the first steps of common bean domestication

by Ana M. GONZÁLEZ[1,#], Fernando J. YUSTE-LISBONA[2,#], María LORES[1], A. Paula RODIÑO[1], Antonio M. DE RON[1], Rafael LOZANO[2] and Marta SANTALLA[1*]

Abstract: Nuñas are native pole beans from South America that possesses the unique property of popping. Nuñas could be a new, nutritious and healthy snack food with potential for North America, Europe, Japan and other industrialized areas, but they are unsuitable for commercial production in temperate zones because they are photoperiod sensitive. Popping ability is quantitatively inherited and controlled mainly by dominant and epistatic effects. Eight QTLs were identified for popping ability on linkage groups 3, 5, 6, 7 and 9 and accounted together for 31% of the phenotypic variance. These QTLs would be good candidates for marker assisted selection to improve popping in nuña bean cultivars for their production as healthy snacks.

Key words: QTLs, marker assisted selection, evolution, *Phaseolus vulgaris*

[1]CSIC, Misión Biológica de Galicia, Departamento de Recursos Fitogenéticos, Pontevedra, Spain (msantalla@mbg.csic.es)
[2]Universidad de Almería, Campus de Excelencia Internacional Agroalimentario, Centro de Investigación en Biotecnología Agroalimentaria (BITAL), Almería, Spain
[#]Both authors contributed equally to this work

Origin and diversity of nuña pop beans

Popping bean or nuña bean (*Phaseolus vulgaris* L., Fabaceae) is traditionally grown in the Andean highlands of South America at 2,000-3,000 m asl, where they are occasionally sold in local markets or consumed at home, thus far known and thought to be an ancient and pre-ceramic landrace (1). It seems probable that nuña beans originated in the Andes, where in some locations from Peru and Bolivia are sympatric with wild and primitive common bean populations, and perhaps at an early stage in the development of Andean agriculture (2). The first selection pressures leading to domestication of common bean could have resulted in the development of popping beans, and it appears that toasting grains was a well-established tradition in the Andes and possibly in Mesoamerica, where early maize races have also been used for popping. However, no evidence of nuña beans in Mesoamerica has been found most likely due to genetic differences between the Mesoamerican and Andean gene pools, which could be responsible, among others, for their contrasting popping ability and photoperiod response (1).

Nuña bean is tropical in appearance, with vigorous climbing growth habit and day-length sensitivity, and is consumed after a quick toasting process. The foremost trait that distinguishes popping bean from all other types of bean is the ability to expand the cotyledons after grains explode in response to heating, which is referred to as popping expansion, similar to popcorn, although the popping mechanism is different. Variation in popping ability, seed size, and color has been observed among ñuña landraces (Fig. 1). Nuñas have a higher content of starch and copper than dry bean varieties and a lower content of protein, phosphorous, iron, and boron. Antinutritional factors such as lectins were higher in raw and boiled nuña samples than in toasted nuñas, while tannin levels did not change from raw to toasted treatments. Overall in-vitro digestibility was slightly lower for toasted nuñas than boiled dry bean (3).

Breeding for popping traits is highly valuable for healthy snacks

Patterns of genetic variability in popping bean germplasm have been studied by using morphologic and molecular data (1, 3, 5, 6, and 7). Expansion coefficient is the most important quality parameter for popping beans. In popcorn, seed moisture content above or below an optimum range will dramatically reduce popping percentage (4). Previous studies also indicated that popping performance of nuña beans was related to the moisture content of seeds (5). Except moisture, little is known on the factors influencing popping ability in bean unlike in maize, where several physic-chemical properties of the grain are well studied (8).

Popping ability should be combined with bush growth habit, early maturity, and photoperiod insensitivity for commercial production in temperate zones. Our studies indicated that additive effects have only minor importance in the total variation of popping performance, and few genes in a mainly dominant fashion and epistasis could be interacting to confer popping ability in common bean. In consequence, more rapid advance will be made in the improvement of popping performance in nuña bean by using a breeding procedure which emphasizes the dominant and epistatic gene effects. Studies evidenced that the backcross with the nuña as the recurrent parent enhanced popping ability among progeny (6). Transgressive segregation was also observed for popping traits (Table 1), suggesting that extreme popping phenotypes resulted from complementary effects of alleles from two parents. Since transgressive segregation relies on additive genetic variation, the extreme phenotypes can be maintained and fixed through artificial selection, providing the potential for improvement of popping ability.

Figure 1. Unpopped (left) and popped (right) seeds of nuña bean landraces

Table 1. Single–locus QTLs, mean values and range for two popping traits measured in 185 recombinant inbred lines (RILs)

QTL	LG[a]	Marker interval	$h^2(a)$[b]	Add[c]	PMB0225	PHA1037[d]	Range RILs
Expansion coeficiente (EC)							
EC3	3 (67.8-71.0)	BMc259-IAC24	4.3	3.7	8.14	57.26	-53.33 – 383.33
EC5	5 (40.6-46.1)	E32M60-BM175	4.6	4.1			
EC7	7 (24.2-36.6)	BM185-BMc294	2.8	-6.1			
EC9	9 (60.9-70.2)	PV-at007-BMc184	3.4	3.4			
Popping dimensión index (PDI)							
PDI3	3 (71.0-84.9)	IAC24-BM287	7.0	3.7	-0.36	25.05	-26.57 – 45.08
PDI5	5 (35.8-37.8)	E32M60-Bmc321	6.9	1.3			
PDI6	6 (2.3-5.0)	Bmc238-E40M60-91	2.2	1.5			
PDI7	7 (24.2-36.6)	BM185-BMc294	6.1	-1.7			

Phenotypic selection for popping ability is laborious and time-consuming. Marker-assisted selection (MAS) approaches have been difficult to apply in the case of complex traits as popping ability, because individual QTLs have small genetic effects which in many cases are also environmentally modulated; hence, the identification of potential candidate QTLs for MAS is crucial. Eight QTLs for expansion coefficient and popping dimension index were detected (Table 1) in an intra-gene pool mapping population generated from the cross PMB0225 (unpopped parent) x PHA1037 (popped parent). These QTLs were located on several linkage groups (LGs 3, 5, 6, 7 and 9) and they together explained 31% of the phenotypic variation; interestingly four of these QTLs co-localized on LG3 and LG7), which explained 21% of the phenotypic variation. These QTLs not only showed stability across significantly correlated traits, in separate and combined environments, but also they are shared QTLs for more than one trait which could be managed simultaneously in a breeding program.

The inheritance of popping ability was shown to be complex. Dominant gene action and additive *x* additive and dominant *x* dominant genetic effects were shown to be important in the genetic regulation of popping. The complexity of the inheritance of popping expansion shows that more complex breeding strategies could be more successful. The discovery of different QTLs with significant genetic effects for popping traits provides ample scope for an effective pyramiding approach, in which candidate QTLs could be simultaneously selected using PCR-based cost-effective marker systems. Therefore, by means of a QTL pyramiding approach, it could be possible to combine QTL alleles with positive effects for popping ability on a day-length-insensitive genotype through molecular breeding; it would allow overcoming the main drawback that has restricted the production and commercialization of nuña beans in temperate regions. ■

Acknowledgements

This work has been funded by a grant PET2008_0167 of the Ministerio de Economía y Competitividad. The authors thank Quival-Frutos Secos El Nogal (Pontevedra, Spain) for technical support and Diputación de Pontevedra for farm facilities. A. Paula Rodiño and Ana M. González were supported by a research contract of the Xunta de Galicia and National Spanish Research Council (CSIC), respectively.